Solid State Power Combiners for Accelerator Applications

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Lee Teng Internship Program

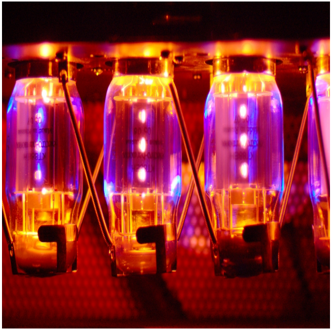
Power Amplifiers

Klystrons (Tube Amplifiers)

High Power (MegaWatts)

In use for almost a century

Prohibitively Expensive

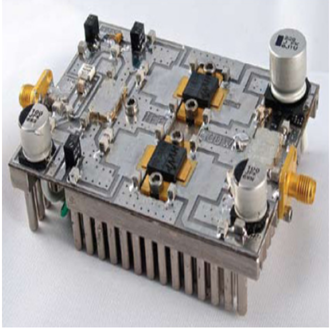


Solid State Amplifiers

Lower Power (KiloWatts)

Requires a combiner

Predictable Performance



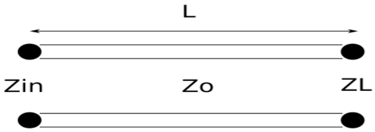
Transmission Line Theory

$$V(z) = V_0^+ e^{-j\beta z} + V_0^- e^{j\beta z}$$

$$I(z) = \frac{V_0^+}{Z_0} e^{-j\beta z} - \frac{V_0^-}{Z_0} e^{j\beta z}$$

$$\Gamma = \frac{V_0^-}{V_0^+} = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$Z_{in} = Z_0 \frac{Z_L + jZ_0 tan(\beta l)}{Z_0 + jZ_L tan(\beta l)}$$

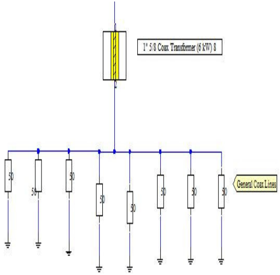


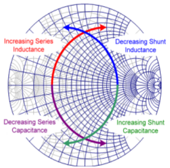
Coaxial Tree Design

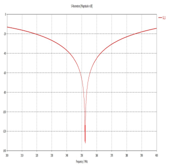
$$Z_0 = \sqrt{Z_{in} Z_L} \quad (\frac{\lambda}{4} \ Transformer)$$

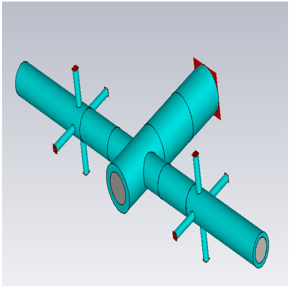
$$Z_{in} = jZ_0 tan(\beta l) \quad (Short - Circuit \ St$$

$$S_{11} \ (dB) = 20 log(\Gamma)$$







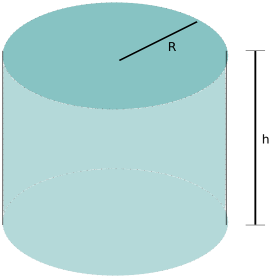


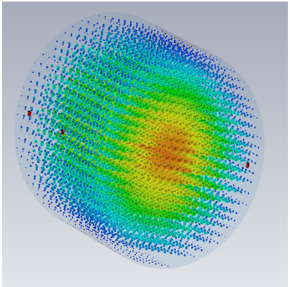
Cavity Combiner Design

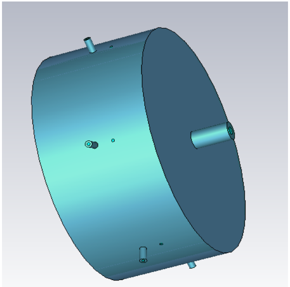
$$f_{m,n,p} = \frac{v_p}{2\pi}\sqrt{\left(\frac{X_{m,n}}{R}\right)^2 + \left(\frac{p\pi}{h}\right)^2}$$

$$Q = \frac{2\pi f_0 U}{P}$$

$$\beta = \frac{Q_0}{Q_{ext}}$$



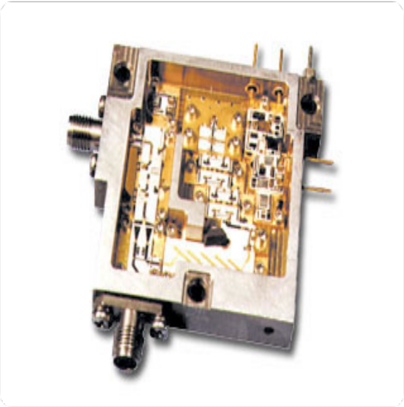


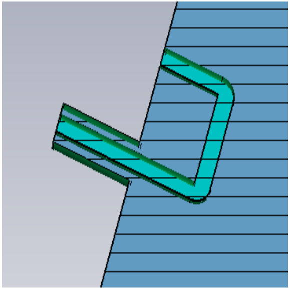


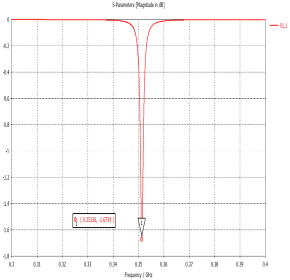
Input Coupler Design

$$\beta = 100$$

$$\Gamma = \frac{1 - N}{N}$$







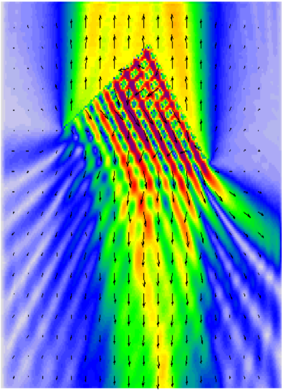
Evaluations of Power

$$\vec{S} = \frac{1}{2}\vec{E} \times \vec{H}^*$$

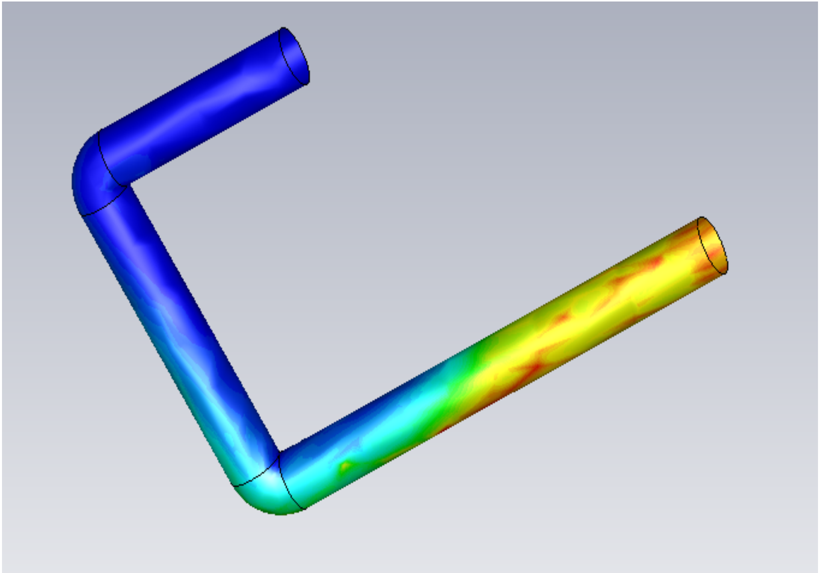
$$P = \int \vec{S} \cdot d\vec{S}$$

$$Loss = \frac{1}{2}R_s \int \vec{H} \cdot \vec{H}^* d\vec{S}$$

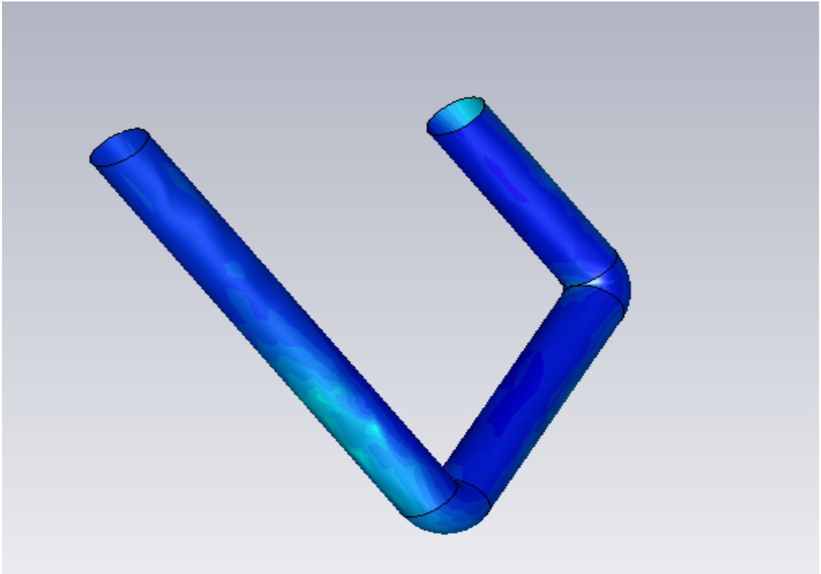
$$R_s = \sqrt{\frac{\omega\mu}{2\sigma}}$$



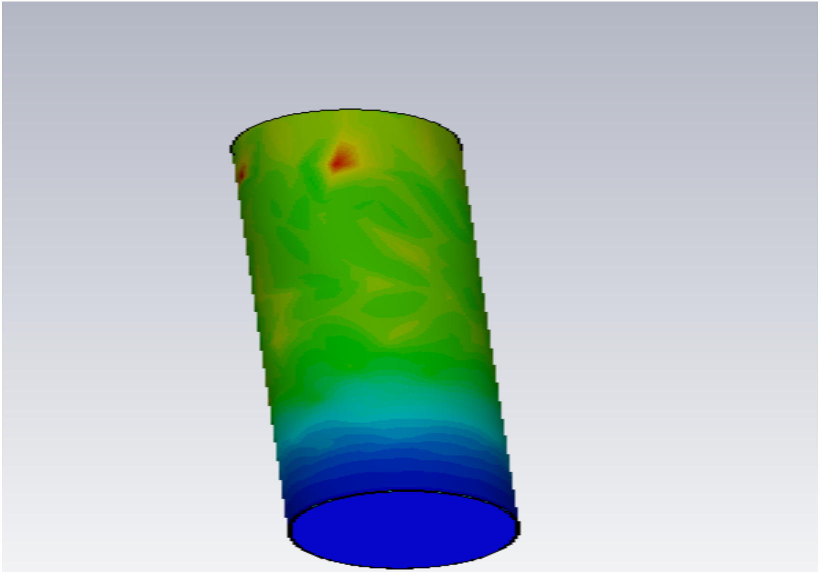
Input Coupler Power Flow



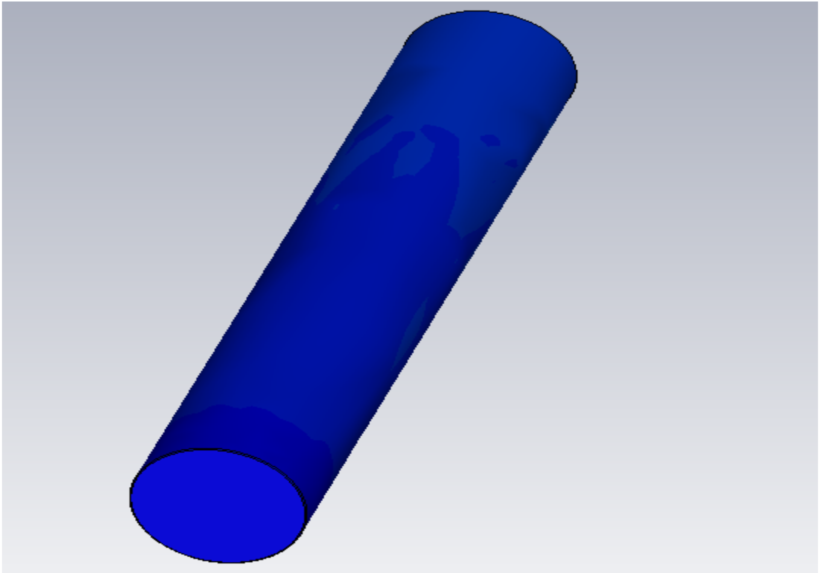
Input Coupler Loss



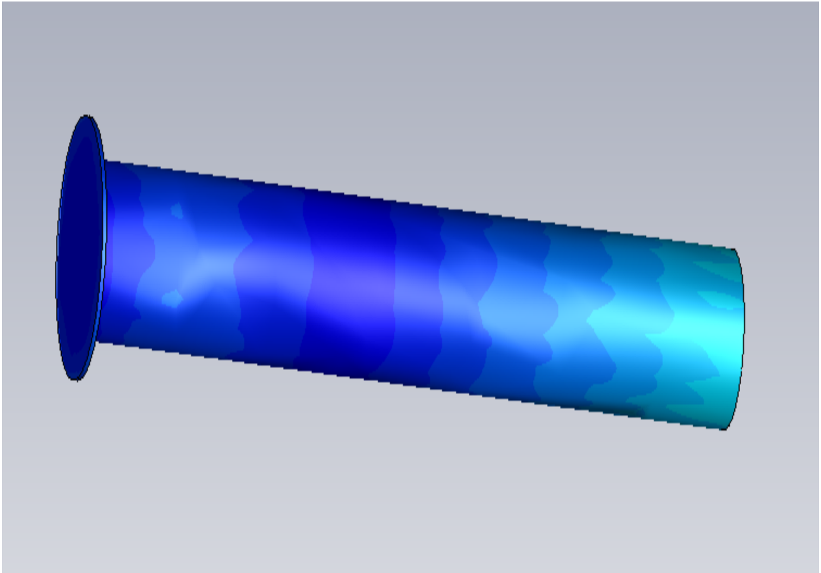
Coaxial Output Coupler Power Flow



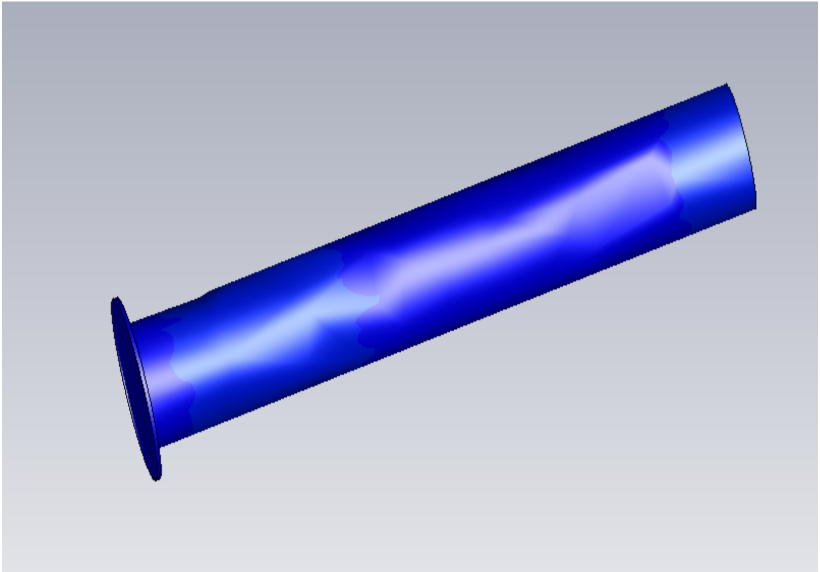
Coaxial Output Coupler Loss



Cylindrical Output Coupler Power Flow



Cylindrical Output Coupler Loss



Acknowledgements

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Good Luck Everybody.